ORIGINAL ARTICLE

Quality improvement of oral medication administration in patients with enteral feeding tubes

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Background: The correct administration of oral drugs to patients on enteral tube feeding presents a special challenge. As patients are usually unable to swallow oral drugs and many drugs should not be crushed, ways have to be found to administer them through the feeding tube. Measures to improve the quality of oral drug administration in patients with enteral feeding tubes may consist of introducing guidelines, training nurses, or giving patient-tailored advice by the pharmacy. An integrated program comprising all these measures is likely to result in the greatest improvements.

Methods: A study was undertaken in two Dutch hospitals to investigate the effect of such an integrated program.

Results: The integrated program in hospital I resulted in a decrease in the number of tube obstructions (odds ratio (OR) 0.22, 95% confidence interval (CI) 0.047 to 1.05). There was a significant decrease in the number of administration errors per nurse in hospital II (OR 0.003, 95% CI 0.0005 to 0.02).

Conclusions: This multidisciplinary program comprising several interventions to promote the correct administration of drugs through an enteral feeding tube results in substantial improvements. As errors concerning administration of drugs to patients with enteral feeding tubes may lead to adverse drug events and loss of effect, these improvements are likely to contribute to a decrease in patient morbidity.

A substantial group of patients in hospital as well as in nursing homes and even in ambulatory care are temporarily dependent on enteral feeding. These patients commonly also use oral drugs which are usually administered through the feeding tube. This means that the solid oral dosage forms such as tablets will either have to be crushed or a liquid oral dosage form or alternative route of administration has to be found. Nurses tend to choose the crushing option as they are generally not familiar with the alternatives (liquid alternatives are recommended by pharmacists but information regarding patients on tube feeding does not routinely reach them). However, the crushing of tablets can cause a number of problems. Firstly, crushed tablets are the most frequent cause of obstruction of feeding tubes.[1–4] Obstructed feeding tubes will often have to be replaced, resulting in increased patient morbidity and cost. Secondly, crushing of tablets destroys the controlled release of enteric coated dosage forms, resulting in a higher initial blood level (and thereby an increased risk of side effects)[5] and a lower blood level towards the end of the dosage interval (and thereby an increased risk of recurrence of symptoms). Depending on the reason for enteric coating, destruction of such a dosage form may lead to irritation of the gastric mucosa by the drug (for example, bisacodyl) or to a loss of effect when the coating is intended to prevent disintegration of the drug by gastric fluids (for example, omeprazole). Finally, crushing of mutagenic or teratogenic drugs may result in harm to the nurse.

In addition to the problems related to crushing solid oral dosage forms, errors can be made when administering drugs through a feeding tube. These errors relate to the administration of a drug in appropriate time relation with ''meals'' and the flushing of the feeding tube before and after the administration of each drug in order to prevent drug-nutrition incompatibilities.

Several studies have shown that all of these problems do occur in practice and that nurses receive little or no training in this specific area of patient care.[6 7] Measures to improve the quality of oral drug administration in patients with enteral feeding tubes may consist of introducing guidelines, training nurses, or giving pharmacy advice. An integrated program comprising all of these measures is likely to result in the greatest improvements. To investigate the effect of such an integrated program, a study was set up in two Dutch hospitals.

METHODS

Study design

An observational study was carried out comparing outcome measurements before and after implementation of the integrated program to improve oral drug administration in patients with enteral feeding tubes. The study was designed as part of the ''breakthrough'' program of the Dutch Institute for Healthcare CBO.[8] Both hospitals agreed to participate in the program, and thus approval for the study was received.

Setting

The study was conducted in two teaching hospitals located in the south of the Netherlands. In hospital I (500 beds) the study was performed on the neurology ward (31 beds), while in hospital II (600 beds) the study was carried out in the neurology ward (40 beds) and in an internal medicine ward (74 beds).

Both hospitals receive pharmaceutical services from the same hospital pharmacy. This hospital pharmacy delivers all tablets and capsules in unit dose packaging. For each drug a medication order is written and a duplicate is sent to the pharmacy for dispensing and computerized medication surveillance (warning of drug-drug interactions and dosage check). The original medication order is put on a cardex and used for preparation and administration of the drugs by nurses. Most of the pharmacy services are delivered from the pharmacy which is located centrally in both hospitals.

Pharmacists or pharmacy assistants spend little or no time on the wards.

The care of patients with enteral feeding tubes before and during the study differed between the two hospitals. In hospital I, tubes with a smaller diameter (Fresenius polyurethane Charriere 8 tubes) were used and they were not routinely flushed throughout the day. In the internal medicine ward in hospital II, Nutricia Flowcare polyurethane Charriere 10 and 12 feeding tubes were used and were routinely flushed six times a day (apart from the flushing when drugs are administered). The neurology ward of hospital II (which used Fresenius polyurethane Charriere 15 tubes) used bolus feeding rather than continuous enteral feeding. The larger diameter and routine flushing of the tubes used in hospital II, as well as bolus feeding, all result in less frequent obstruction of feeding tubes than in hospital I.

Before the study

In both hospitals nurses are trained in the administration of drugs through enteral feeding tubes by other nurses without a formal training program. For the handling of enteral feeding tubes, formal training programs do exist in both hospitals. Nurses have little knowledge of controlled release, enteric coated dosage forms or mutagenic/teratogenic drugs. The hospital pharmacy is not systematically asked for advice concerning administration of oral drugs to patients on feeding tubes.

Interventions

In both hospitals a multidisciplinary project team was formed to implement the planned interventions. Each project team consisted of a (head) nurse, quality manager, dietician, pharmacy technician, and a hospital pharmacist. The following interventions were gradually implemented over a period of 2 months (after a baseline period of 3 months):

- daily ward visits by pharmacy technicians;
- ''enteral feeding tube'' contraindication in pharmacy computer;
- ''do not crush'' icon on unit dose labels;
- setting up a database of oral dosage forms;
- detailed working instruction for nurses;
- short version of this working instruction on the medication cart: the five golden ''tube rules'';
- stamp with text ''enteral feeding tube''.

Daily ward visits by pharmacy technicians

During these visits the technicians met with the responsible nurse who informed them which patients had recently started enteral tube feeding. The technician screened the medication of these patients (and of patients already known to be on enteral tube feeding) and suggested alternatives for drugs that cannot be crushed. The technician also advised on the correct administration of drugs that can be crushed. For this there are two options: (1) crushing the tablet with a tablet crusher (''crush method'') or (2) dispersing the tablet in a syringe filled with 10 ml of water (''dispersing method''). The latter method is advised only if the tablet will disperse completely within 2 minutes. Finally, advice on compatibility with enteral feeding was given—for example, phenytoin,[4 9–11] levothyroxin.

''Enteral feeding tube'' contraindication in pharmacy computer

Patients with enteral feeding tubes were labeled as such in the pharmacy computer. All enteric coated and modified release drugs were also labeled. Thus, when such a drug is entered into the computer for a patient labeled as being fed by an enteral tube, a computer alert will be generated.

''Do not crush'' icon on unit dose labels

A special icon was printed on all unit dose labels of enteric coated and modified release drugs (fig 1).

Setting up a database of oral dosage forms

In this database all oral dosage forms available from the hospital pharmacy are entered, together with information concerning optimum time of administration in relation to meals and in relation to enteral feeding; the presence of gluten; whether enteric coating or a controlled release system is present; alternative dosage form for administration through the feeding tube or for administration via an alternative route; whether the ''dispersing method'' is possible; whether crushing is possible; background literature; and information sources. This database can be used by the pharmacy assistants when giving advice to nurses on the wards.

Detailed working instruction for nurses

A detailed working instruction was prepared which dealt with all aspects of administration of drugs through an enteral feeding tube. This working instruction was communicated to all nurses on the study wards in a formal training session.

Short version of the working instruction on the medication cart: the five golden ''tube rules''

A plasticised card was prepared with the five most important rules for appropriate administration of drugs through an enteral feeding tube:

- stop the enteral feeding before administering drugs;
- flush the enteral feeding tube;
- crush only what can be crushed;
- use the ''dispersing method'' when possible and do not mix different tablets;
- flush after administering each drug.

Stamp with text ''enteral feeding tube''

This stamp is to be used by nurses to print the text ''enteral feeding tube'' on medication orders of patients with enteral feeding. It serves as additional information to the hospital pharmacy (complementary to the ward visit).

Measurements

As obstruction of enteral feeding tubes was a relatively frequent complication in hospital I, this was the main outcome of interest in this hospital. The number of days per patient from the start of tube feeding until the first obstruction, the number of days from the first to the second obstruction (and so on), and the number of days from the last obstruction to the end of tube feeding were counted. As a secondary end point, the use of one or more problem drugs

Figure 1 ''Do not crush'' icon which is printed on unit dose labels.

(drugs that cannot be crushed for various reasons) still administered through the feeding tube was measured. Again, the number of days from the start of tube feeding until the day of first use of one or more problem drugs was counted (comparable to the outcome parameter ''obstruction''). The number of obstructions was compared before and after implementation of the program. The secondary end point was analysed in the same way.

In hospital II the pilot phase showed that obstructions did not occur frequently, so this was not used as an end point. Instead, a ''disguised'' observation[12] of nurses when they prepared and administered drugs to patients with feeding tubes was carried out. The observation was ''disguised'' in the sense that the actual goal was not communicated to the nurses but they were told that they were being observed for a work load assessment. All observations were written on a special form and compared with the working instruction and with the database information. Deviations were counted as administration errors. In the dataset, for a given drug observed to be administered by a given nurse (nurse level), it was noted whether one or more errors occurred (as yes or no). This was also done for a given drug administered to a given patient (patient level). The errors were classified as enteral feeding not interrupted during drug administration, enteral feeding tube not flushed before administration of first drug, drug crushed that may not be crushed, drug dispersed that may not be dispersed, enteral feeding tube not flushed after drug administration, mixing of different drugs when crushing or dispersing. Although the intervention was not aimed at preventing the serious error ''connection of syringe used for enteral feeding with vascular access devices'', the observation would reveal any such errors.

In both hospitals the study consisted of two measurement periods: before all interventions and after implementation of all interventions (except for the database which continued to be constructed at the end of the study). Measurements were also performed during implementation of the interventions but these were not included in the data analysis.

Data analysis

All data were entered into MS Excel 2000 and analysed using S-PLUS Version 6.0. For comparison of both end points in hospital I before and after the intervention, a multiplicative intensity model was used to calculate a hazard ratio. For comparison of both end points in hospital II before and after the intervention, multilevel logistic regression analysis was used on either the nurse or the patient level to calculate an odds ratio. For all end points a 95% confidence interval was determined (the difference between before and after the intervention was considered statistically significant if it did not include 1).

RESULTS

In hospital I, 10 patients were observed before the interventions had been implemented and 12 patients afterwards. In hospital II, 19 nurses with 96 drug administrations in nine patients were observed before the interventions had been implemented and 17 nurses with 87 drug administrations in seven patients were observed after the interventions had been implemented. Table 1 shows the primary and secondary end points (as hazard ratios in hospital I or odds ratios in hospital II) for all hospitals together with the 95% confidence intervals.

In hospital I the difference in the number of obstructions was not statistically significant, but a trend towards improvement after the interventions was seen. The 95% confidence interval of the number of problem drugs was too wide to provide valuable information. In hospital II there was a statistically significant difference in the end points between the two periods. In hospital II the administration errors were classified.

Table 1 Mean end points for both hospitals: comparison before and after interventions

End point	Hazard ratio (hospital I) or odds ratio (hospital II)	95% CI
Hospital I		
No of obstructions related to days of tube feeding (after intervention *v* before)	0.22	0.047 to 1.05*
No of problem drugs related to days of tube feeding (after intervention *v* before)	–†	–*†
Hospital II		
Administration errors per nurse (after intervention *v* before)	0.003	0.0005 to 0.02‡
Administration errors per patient (after intervention *v* before)	0.005	0.0003 to 0.072‡

*Multiplicative intensity model.
†Analysis not possible due to small numbers of problem drugs per patient (very wide confidence interval).
‡Multilevel logistic regression.

Table 2 Classification of administration errors in hospital II before and after the interventions

	Before intervention (% of 96 administrations)	After intervention (% of 87 administrations)
No error	23 (24)	82 (93)
Enteral feeding tube not flushed before administration of first drug	11 (11)	0 (0)
Drug crushed that may not be crushed	26 (27)	3 (3)
Mixing of different drugs when crushing or dispersing	36 (38)	3 (3)

Table 2 shows the number and type of administration errors per class before and after the interventions. As can be seen from this table, most errors before the interventions concerned the crushing of tablets that cannot be crushed and the mixing of different drugs. The number of errors in all classes was significantly reduced after the interventions. The serious error ''inadvertent connection of syringe used for enteral feeding with vascular devices'' did not occur either before or after the intervention.

DISCUSSION

The correct administration of oral drugs to patients with enteral tube feeding presents a special challenge. As patients are usually unable to swallow oral drugs, ways have to be found to administer the drugs through the feeding tube. Several studies have shown that nurses generally rely on the crushing of tablets to accomplish this, but many drugs such as controlled release tablets, enteric coated tablets, and cytostatic drugs should not be crushed. Finding alternative routes of administration or substituting the tablets with liquid dosage forms is often a more appropriate solution. For liquid forms the sorbitol content should be considered as this may cause diarrhea,[4 13 14] as well as the administered volume (for example, when administering injectables orally).

In our hospitals we found that a multidisciplinary intervention program which focused on promoting the

correct administration of drugs to patients with enteral feeding tubes was effective in reaching its goals (fewer obstructions, fewer problem drugs, and fewer administration errors per nurse). This study is one of the first to report the advantages of such an interdisciplinary program. Belknap *et al*[1] have previously shown that lower rates of obstruction of enteral feeding tubes are associated with assistance from the pharmacy service to ensure liquid forms of medications, nurses' attendance at a training program, and not routinely crushing problem drugs.

One of the limitations of our study is the fact that we did not use formal time series analysis or any other method to rule out time trends. We cannot therefore be entirely sure that the effects seen are not the result of such time trends. However, as most of the measured effects are quite substantial and we are not aware of any other changes in the nursing routine, a time trend seems unlikely. Another limitation is the fact that we conducted the study in only two Dutch hospitals which may restrict the generalisability of our results. However, it is clear from the literature that comparable difficulties with the administration of drugs through enteral feeding tubes are found in many different hospitals.[14] The interventions we describe are relatively simple and may therefore also be of use in other hospitals. Whether this will result in equally large effects will depend on the cooperation between the different disciplines involved and on the situation before implementation of the interventions.

Finally, we did not measure any clinically relevant end points such as patient morbidity and/or mortality. For interventions regarding drug safety, such end points are recommended as they can demonstrate actual patient effects. However, in view of the relatively low incidence of these effects, a much larger sample size would be needed which was beyond the scope of this ''breakthrough'' study. Furthermore, the intermediate end points (number of problem drugs and administration errors) we measured are likely to result in patient morbidity and/or mortality,[5 14] and the complications of tube obstruction (our other end point) are obvious.

We conclude that a multidisciplinary program comprising several interventions to promote the correct administration of drugs through an enteral feeding tube can result in substantial improvements. To assure that this success is maintained, the competency based in-service training program should be expanded to include training in the administration of drugs through enteral feeding tubes. Furthermore, by continuing their daily ward visits, pharmacy technicians provide a regular reminder of the intervention program.

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